Reclamation has a strategic plan to accomplish its mission in accordance with the Government Performance and Results Act. Within the strategic plan, science and research is one of six principles that guide how Reclamation will achieve our strategic, long-term, and annual goals. The goals and strategies below are excerpted from the 2001 Performance Plan and 2000-2005 Strategic Plan. We have quoted them here to tie these to our specific research focus areas.

Reclamation's Goals	*Reclamation's Strategies*
Enhance fish and wildlife habitat	**"Reclamation conducts research on enhancing environmental resources such as fisheries protection, wetlands development, and habitat evaluations and improvements for endangered species. For example, research activities sponsor the development of fish-friendly pumps, screening, louver mechanisms, and diversions. This research combines fisheries biology with the engineering disciplines to investigate the needs of fish as they pass through our facilities."**
Protect water quality **Assess and improve water quality**	**"Research is critical to finding the best technologies and practices to improve water quality. We support research in the areas of reservoir water quality monitoring, non-point source pollution, pollutant mapping, and tools to enhance water quality."**
Manage project land resources	**"Continues pest management research activities. Invasive species such as purple loosestrife, salt cedar, and knapweed can take over wetlands and riparian areas, displacing native species and using large amounts of water. We are investigating bio-control methods to eradicate these species while protecting natives. In sites where bio-control techniques are successful, we are researching proper methods and species for revegetation to restore natural conditions."**

Chapter 2:
Improving Water Delivery Reliability

"We are continually faced with a series of great opportunities brilliantly disguised as insoluble problems." — John W. Gardner

Improving water delivery reliability by reducing and preventing fish impacts

The Endangered Species Act establishes a federal responsibility to address endangered species issues. Federal agencies also have an obligation under an Executive order to improve recreational fish habitat.

Understanding fish habitat requirements is critical to fulfilling our goal of providing reliable water supplies for agriculture, industry, hydropower, and urban needs. Furthermore, we all enjoy streams, rivers, and reservoirs where fish swim in clean water and crawdads play under shady banks. Healthy streams aren't just a luxury, they keep just about everyone alive and happy—from irrigators to power users, from people in cities to people in boats.

Fish are sometimes killed, injured, or displaced into unsuitable habitats when they are drawn into hydroturbines or entrained into irrigation canals. Reclamation operations are sometimes curtailed or suspended to avoid such adverse effects, leading to the loss of valuable water deliveries or resulting in costly mitigation measures. Improved methods and technology for reducing entrainment can preserve greater numbers of fish and simultaneously allow more flexibility in water supply management.

Even the smallest dams and other obstructions can restrict the upstream and downstream movements of fish. This makes it difficult for anadromous fish to migrate to the sea as juveniles and to return later as spawning adults, or for resident fish to fully use their stream habitat. The Science and Technology Program is seeking ways to facilitate fish passage while dams and other structures remain in place.

Basic knowledge about the biology and ecology of fish species and entire populations helps establish solid scientific information necessary to guide decisions about the timing, quantity, and quality of flows. This knowledge can also help us determine when flows can safely be diverted for other purposes and how large those diversions can be. Enabling fish passage and reducing fish losses are necessary to provide healthy stream systems for the future.

Science and Technology Program projects are testing various methods to improve fish exclusion, guidance, and entrainment. These projects include:

- Bioengineering fishways and passage and guidance structures
- Designing and using physical barriers to remove debris and invasive species such as mitten crabs
- Guiding fish using underwater strobe lights, fish crowders, and behavioral barriers such as louvers

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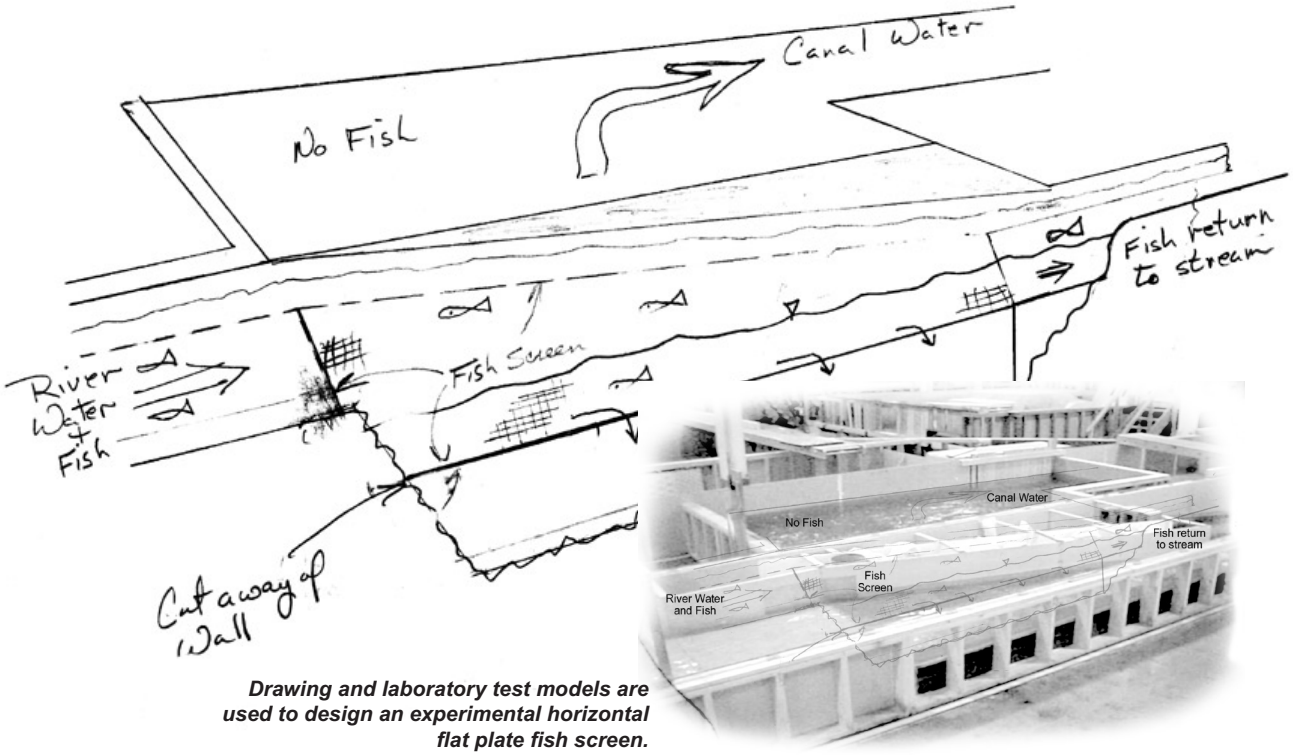
- Using "fish friendly" pumps to move or lift fish
- Improving methods to determine the numbers and types of fish entrained into irrigation canals
- Improving fish passage around low-head diversion dams
- Evaluating fish responses to prototype vertical and horizontal screens in the laboratory
- Using biotelemetry to study individual fish behavior
- Using light traps to improve salvage of young fish
- Describing the fish community below Reclamation facilities
- Using underwater fish counters at fish ladders
- Assessing flow needs for successful hatching in salmon reeds
- Evaluating holding effects on entrained fishes

By finding out about how fish live and how we can provide water supplies while keeping fish in our streams and reservoirs, fisheries research will help ensure sustainable water uses.



Drawing and laboratory test models are used to design an experimental horizontal flat plate fish screen.

Water Quality

Finding ways to assess and improve water quality

Water is constantly on the move. It brushes against streambeds, flows through irrigated fields, and runs into towns, picking up sediments, nutrients, salts, and minerals as a normal process. It may also pick up heavy metals, pesticides, antibiotics, and other pharmaceuticals as well as excessive levels of fertilizers, salts, and minerals.

Fish and aquatic animals require appropriate temperatures, suitable concentrations of dissolved oxygen, and other important physical and chemical conditions. Municipal and industrial uses highlight the importance of water quality in our water deliveries. Reclamation's Science and Technology Program is finding new and more effective ways to determine water quality and what will happen under various operating scenarios. This information will be invaluable for determining ways to manage our facilities and for working with partners and stakeholders to improve water quality.

The Science and Technology Program's water quality research addressed many of these issues in FY00 and FY01, including:

- **Temperature.—**Providing suitable downstream water temperatures is crucial to protect fisheries. The program evaluates the effectiveness of recently installed selective withdrawal facilities that regulate downstream temperatures and improve water quality in dam releases. These insights help Reclamation make operation and maintenance decisions and improve future designs.
- **Dissolved oxygen.—**Without the proper concentrations of oxygen, fish cannot survive. The program found ways to mix low oxygen turbine water with spillway water to effectively increase dissolved oxygen to acceptable levels at Canyon Ferry Dam.
- **Sediment.—**Collecting and analyzing sediment data is expensive. The amount of data collected shrinks, while the need increases—so the program developed a series of "clean" (non-contaminating) suspended sediment samplers to collect sediment more efficiently while reducing collection costs.
- **Selenium.—**Selenium occurs naturally, but too much can harm aquatic birds. The program is working with federal, state, and local agencies and universities to develop better methods to predict selenium loads in agricultural drain water. Field studies are determining rates of selenium leaching, soil types, and ground water levels. Armed with this knowledge, Reclamation can better predict and manage selenium concentrations in drain water.
- **Pathogens.—**Pathogens and nutrients from leach fields can reach reservoirs. The program is investigating potential contamination in Pineview Reservoir, Utah.
- **Xenobiotics.—**Chemicals such as caffeine, nicotine, and flame retardants pass through sewage treatment into the environment. The program was one of the first to recognize and study this new threat and is working with the National Park Service, Nevada Division of Wildlife, and others to determine how these chemicals affect fish in the Las Vegas Wash, Nevada.

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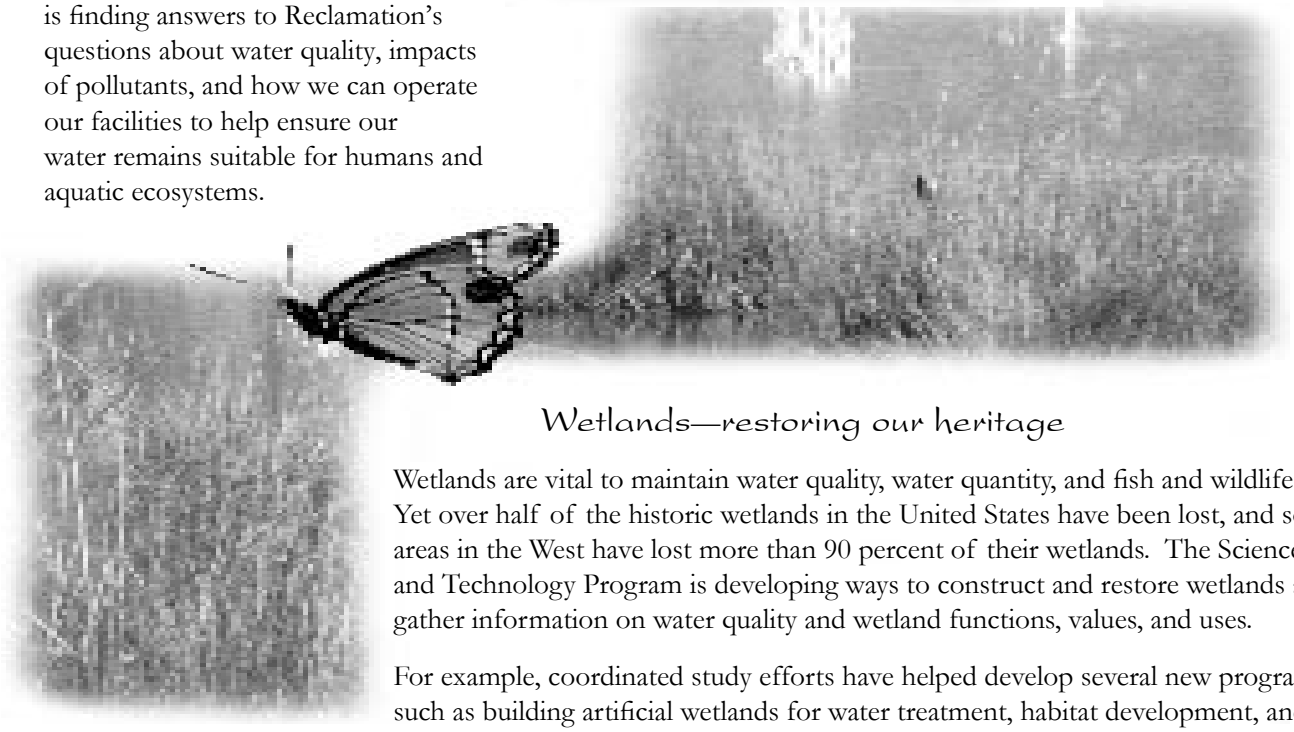
We are developing ways to better evaluate water quality techniques such as:

- **Field techniques and laboratory methods.—**Working with the U.S. Geological Survey and the National Research Council to find more accurate, low-cost, and easy-to-use bioassessment methods and environmental indicators.
- **Models.—**Enhancing and applying reservoir water quality models to Reclamation reservoirs to improve operations. We developed a graphical user interface for the Environmental Protection Agency's Water Quality Analysis Simulation Program to trace what happens to toxins in streams, available at: <http://www.ids.colostate.edu/projects/wasp/>. The program animates events and changes in temperature, dissolved oxygen, velocity, retention time, and concentrations.

Karla Brown of the Gunnison Basin Selenium Task Force thanked the program for its work in selenium research. "This information has proved vital to the Task Force as we attempt to understand how new development may be associated with new sources of selenium. . . . We are looking forward to additional successful collaborative efforts with these Reclamation scientists, making a difference we can see locally."

With these techniques and more, the Science and Technology Program is finding answers to Reclamation's questions about water quality, impacts of pollutants, and how we can operate our facilities to help ensure our water remains suitable for humans and aquatic ecosystems.



Wetlands—restoring our heritage

Wetlands are vital to maintain water quality, water quantity, and fish and wildlife habitat. Yet over half of the historic wetlands in the United States have been lost, and some areas in the West have lost more than 90 percent of their wetlands. The Science and Technology Program is developing ways to construct and restore wetlands and to gather information on water quality and wetland functions, values, and uses.

For example, coordinated study efforts have helped develop several new programs, such as building artificial wetlands for water treatment, habitat development, and education and research.

Reclamation and others will use this information to manage watersheds, water projects, and aquatic ecosystems.

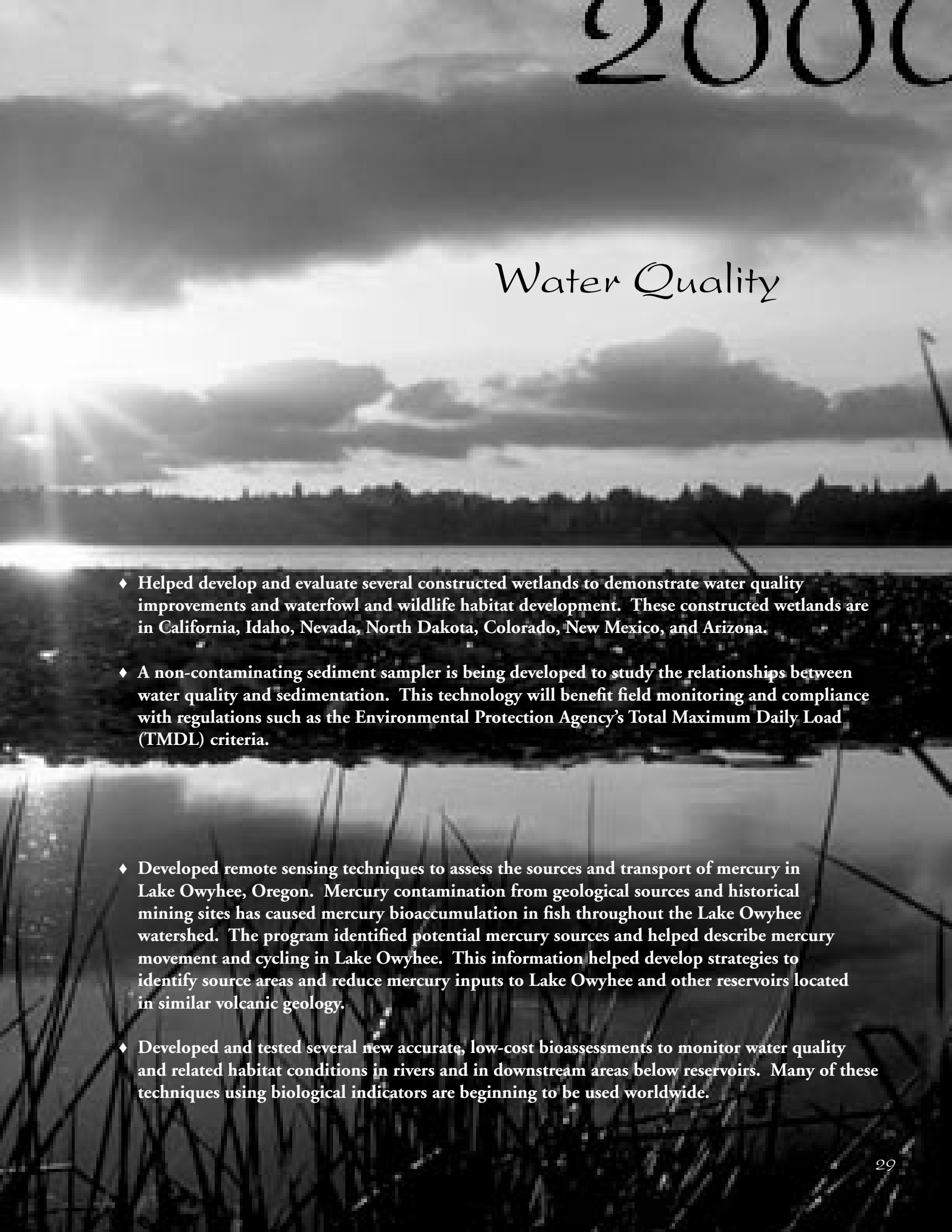
Knowing how Reclamation facilities interact with the environment is crucial. Over the past decade, Science and Technology Program research has provided invaluable insights to help Reclamation facilities operate more efficiently and improve water quality.

- Improved selective reservoir withdrawal techniques to meet water temperature standards for endangered species below Shasta, Hungry Horse, Flaming Gorge, Folsom, and other dams. For example, before 1997, Reclamation had to spill cold water through Shasta Dam's low-level river outlets instead of through the power house. A unique selective withdrawal system, using knowledge gained through the Science and Technology Program, now provides the required water temperature for fish while continuing releases through the powerplant to generate more electricity.

- Performed environmental and water quality studies related to operating the temperature control device on Shasta Dam. Studies showed decreased nutrient concentrations, localized increases in particulate organic matter, and increased phytoplankton and zooplankton downstream because of releases of productive epilimnetic waters from Shasta Lake.

- Experimented with releases from Canyon Ferry Reservoir to demonstrate how downstream oxygen levels could be increased. This information will help design structural or operational modifications to improve water quality to protect downstream fish and other biota.

- Contributed to several water quality and limnological studies on Lake Mead, Lake Powell, and Navajo Reservoir to help evaluate water quality conditions and to help identify environmental problems and possible solutions for drinking water quality, recreation, aquatic habitat, and fisheries.



Water Quality

- **Helped develop and evaluate several constructed wetlands to demonstrate water quality improvements and waterfowl and wildlife habitat development. These constructed wetlands are in California, Idaho, Nevada, North Dakota, Colorado, New Mexico, and Arizona.**

- **A non-contaminating sediment sampler is being developed to study the relationships between water quality and sedimentation. This technology will benefit field monitoring and compliance with regulations such as the Environmental Protection Agency's Total Maximum Daily Load (TMDL) criteria.**

- **Developed remote sensing techniques to assess the sources and transport of mercury in Lake Owyhee, Oregon. Mercury contamination from geological sources and historical mining sites has caused mercury bioaccumulation in fish throughout the Lake Owyhee watershed. The program identified potential mercury sources and helped describe mercury movement and cycling in Lake Owyhee. This information helped develop strategies to identify source areas and reduce mercury inputs to Lake Owyhee and other reservoirs located in similar volcanic geology.**

- **Developed and tested several new accurate, low-cost bioassessments to monitor water quality and related habitat conditions in rivers and in downstream areas below reservoirs. Many of these techniques using biological indicators are beginning to be used worldwide.**

Invasive Species Control

Preventing damages, protecting facilities, and ensuring water deliveries

Economic and environmental chaos can result when non-native plants and animals invade areas with few or no natural predators. These pests damage our infrastructure; obstruct flow; prevent access for maintenance and recreation; cause structural damage; and harm system operations, water quality, and habitat. The annual dollar value of lost irrigation water is estimated as high as $288 million, and the annual dollar value of lost power generation along the Colorado River alone is estimated to be as great as $43.5 million. Reclamation must combat these invasive species to protect our facilities and ensure water delivery.

Invasive species cost the U.S. economy hundreds of millions of dollars a year. Each day, noxious weeds (like leafy spurge and yellow star thistle) move into about 4,600 acres, choking out native plants and punching an economic whallop of about $140 million a year. Thirsty exotic species like salt cedar with 100-foot-deep roots "drink" critical water supplies and choke out native habitats along rivers. Salt cedar spread rapidly over the past 30 years and consumes an estimated 2.5 million acre-feet of water a year in the west. Purple loosestrife chokes waterways and wetlands, causing an estimated $46 million in damages a year.

Reclamation's Science and Technology Program is attacking the problem on several fronts. We study the life cycle of a species to determine the best times to move against it to prevent spreading and reproduction. To determine optimal ways to combine and use techniques, we are examining traditional pest management methods such as herbicides and mechanical controls. For example, cutting the plant at the root and then spraying the remaining stem with pesticides may be most effective. However, traditional methods can be costly and environmentally damaging.

Reclamation's Science and Technology Program seeks out the species' natural enemies and finds ways to safely use these enemies to control invasive species. Often, we can find predators that rely solely on that plant or animal and will eat nothing else. We do extensive tests to ensure that adding this predator won't harm the environment. After this, we can introduce that predator into the ecosystem to bring the invasive species into a controlled equilibrium.

Reclamation released insects that eat only purple loosestrife at the Winchester Wasteway, where dense growth threatened to block waterflows and vital habitat. The insects and loosestrife reached a balance where both are present at low levels. Because of this research, control costs were reduced to $20,000 for an initial treatment and a few thousand dollars a year to apply and monitor the insects in a similar situation. This is less than one-fifth of the cost of traditional treatment with herbicides.

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Salt cedar web site:
<http://arsserv0.tamu.edu/lewis/saltc.htm>

Such findings, coupled with knowledge about the species, help Reclamation facility managers develop effective integrated pest management plans. The program helps local facility operators to develop and implement these plans. As new technology becomes available, the program shows operators how to use and understand these new control methods.

The Science and Technology Program provides technical assistance, special studies, and demonstration projects to promote integrated pest management concepts and to solve specific pest problems. Demonstrations at Reclamation's facilities show how effective these technologies can be and how operators can adapt the technology to Reclamation's operation patterns and practices. For example, insects that control leafy spurge were only tested in weed patches shaped in circles and squares. Yet Reclamation's irrigation canals and rights-of-way are long, narrow corridors. Our research showed that insects respond to long linear strips of weeds in the same way they would to a large circular patch. By understanding how predatory insects disperse, we can establish the most effective release patterns that minimize costs and maximize effectiveness.

Reclamation is working with many partners to monitor and counter the continual threat from established and new invasive species. Through this cooperation, we can protect our facilities, the environment, and the Nation's economy from these hordes of invaders.

Jim Gaza, Central Arizona Project, aqueduct maintenance foreman, praises the research,"The work Reclamation did in developing an aquatic weed management program using triploid grass carp saves $1 million dollars a year."

The Science and Technology Program is working on the outbreak of Giant Salvinia in the Palo Verde Irrigation District drainage system in Reclamation's Lower Colorado Region. We are demonstrating ways to eradicate the menace and rehabilitate the drains.

"Had we used herbicides to control the 24,000 plus acres of purple loosestrife at the Winchester Wasteway, it would have cost $100,000 for material and labor—not to mention the costs for NEPA and other regulatory compliances. Now we are working together on biocontrol agents for thistles, knapweeds, saltcedar, leafy spurge, and others. This work will help our noxious weed control program in the future." Wes Green, Management Agronomist, Pacific Northwest Region

The Science and Technology Progaram is demonstrating new methods to eradicate salt cedar with insects that only eat salt cedar. In 2001, researchers started testing this potentially effective, low-cost, and environmentally friendly method of eradication at sites along the Arkansas River.